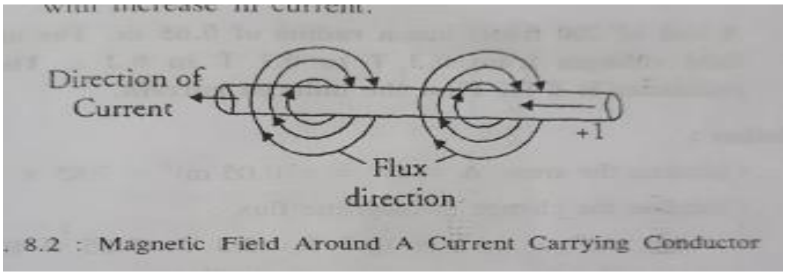
WEEK-8

DESCRIBE THE MAGNETIC FIELD AROUND A CURRENT CARRYING CONDUTOR:

Magnetic Field Around a Current Carrying Conductor

When an electric current flows through a conductor, a **magnetic field** is produced around it. This phenomenon was first discovered by Hans Christian Oersted in 1820.



8.2 : Magnetic Field Around A Current Carrying Conductor

1. Shape of the Magnetic Field

- The magnetic field lines around a **straight current-carrying conductor** are **concentric circles**.
- These circles lie in planes perpendicular to the conductor.
- The conductor acts as the center of these circular magnetic field lines.

2. Direction of the Magnetic Field (Right-Hand Thumb Rule)

The direction of the magnetic field is determined by the **Right-Hand Thumb Rule**:

- Hold the conductor in your **right hand**.
- Let the **thumb point in the direction of current**.
- The **curled fingers** show the direction of the magnetic field lines.

If current flows:

- **Upward** → magnetic field circulates **anticlockwise** (when viewed from top).
- **Downward** → magnetic field circulates **clockwise**.

3. Strength of the Magnetic Field

The magnetic field strength depends on:

1. **Magnitude of current (I)**: More current → stronger magnetic field.
2. **Distance from the conductor (r)** :Field strength decreases as distance increases.
    - $B \propto \frac{1}{r}$

3)**Nature of medium:** Magnetic field is stronger in materials with high magnetic permeability.

4. Expression for Magnetic Field

For a long straight conductor:

$$B = \frac{\mu_0 I}{2\pi r}$$

Where:

- B= Magnetic flux density
- μ_0= Permeability of free space
- I= Current
- r= Distance from conductor

STATE AND EXPLAIN CORK-SCREW RULE:

CORK SCREW RULE (MAXWELL'S RIGHT-HAND SCREW RULE)

Statement:

The **Cork Screw Rule** states that:

If a right-handed screw is rotated so that it advances in the direction of current in a straight conductor, then the direction of rotation of the screw gives the direction of the magnetic field lines around the conductor.

This rule is also known as **Maxwell's Right-Hand Screw Rule**, given by James Clerk Maxwell.

Maxwel's Cork Screw Rule : Hold the screw in your right hand, so that the tip points the direction of current. Rotate the screw such that it moves into the cork (i.e. in the direction of current). Then the direction of rotation of your hand gives the direction of flux, surrounding the current carrying conductor as shown in Fig. 8.3.

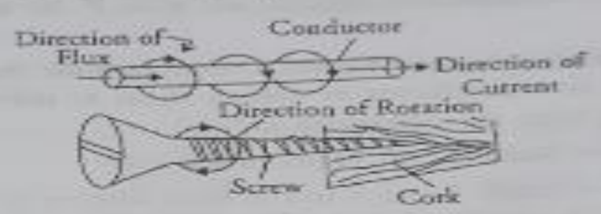


Fig. 8.3 : Maxwel's Cork Screw Rule

RIGHT HAND THUMB RULE:

This Rule give us direction of Current and direction of flux .

Right Hand Thumb Rule : Grip the current carrying conductor with your right hand, so that the thumb is in the direction of current and the other fingers encircling the conductor. Then the direction of

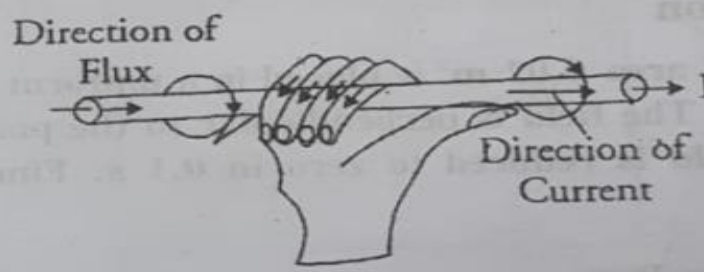


Fig. 8.4 : Right Hand Thumb Rule

fingers, encircling the conductor, will give the direction of flux surrounding the conductor as shown in Fig. 8.4.

STATE AND EXPLAIN FARADAYS LAWS OF ELECTROMAGNETIC INDUCTION:

Faraday's Laws of Electromagnetic Induction:

Michael Faraday discovered the laws of electromagnetic induction in 1831. These laws explain how an **emf (electromotive force)** is produced when the magnetic flux linked with a circuit changes.

1)**First Law of Electromagnetic Induction**

Statement:

Whenever the magnetic flux linked with a closed conducting loop or circuit changes, an electromotive force (EMF) is induced in that circuit.

Explanation:

Change in flux can occur by:

● Moving a magnet near a coil,

● Changing the coil's area or orientation,

● Varying the strength of the magnetic field.

● The induced EMF lasts only while the flux is changing.

2)Faraday's Second Law :

Statement:

The magnitude of the induced EMF in a circuit is directly proportional to the rate of change of magnetic flux linked with the circuit.

Explanation:

This law provides a way to calculate the magnitude of the induced EMF. If the magnetic flux changes quickly (a high rate of change), a larger EMF is induced, and if it changes slowly, a smaller EMF is induced.

Mathematical Representation:

The law is expressed as:

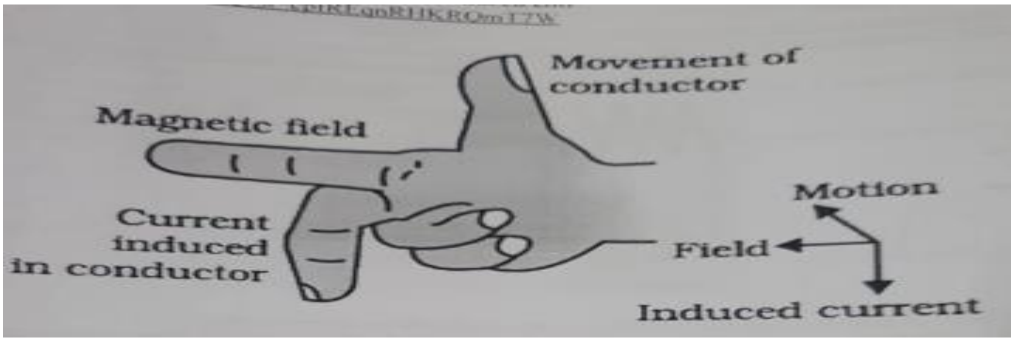
$$E = -N\,(d\Phi/dt)$$

- E represents the induced electromotive force (EMF) in volts.
- N is the number of turns in the coil.
- Φ (Phi) is the magnetic flux in webers (Wb).
- dΦ/dt is the rate of change of magnetic flux with respect to time (time in seconds).

*The **negative sign** indicates the direction of induced emf (given by Lenz's Law).

STATE AND EXPLAIN FLEMING'S RIGHT HAND RULE:

FLEMINGS RIGHT HAND RULE:



Statement of Fleming's Right Hand Rule : Stretch the three fingers, the fore finger, the thumb and the middle finger of your Right hand, mutually perpendicular to each other. Hold the hand such that the fore finger indicates the direction of field flux, the thumb indicates the direction of motion of the conductor, then the middle finger gives the direction of E.M.F induced in the conductor.

EXPLAINATION:

Conductor is moving from right to left in the magnetic field. Hence Thumb is held in the direction of motion of the conductor. The field flux is from top to bottom. Hence the fore finger is held in the direction of flux. Now, according to Fleming's right hand rule, the direction of E.M.F. induced in the conductor is in the direction of middle finger.

STATE AND EXPLAIN LENZ'S LAW:

Lenz's Law

Statement:
Lenz's Law states that *the direction of the induced emf (or induced current) in a circuit is such that it opposes the change in magnetic flux that produces it.*

It gives the direction of induced current in electromagnetic induction.

Explanation

When the magnetic flux linked with a conductor changes, an emf is induced in it according to Michael Faraday's Law of Electromagnetic Induction.

Lenz's Law tells us the direction of this induced emf.

- If the magnetic flux increases, the induced current flows in a direction that produces a magnetic field opposing the increase.
- If the magnetic flux decreases, the induced current flows in a direction that tries to maintain the original flux.

Mathematically, Faraday's law including Lenz's law is written as:

$$e = -\frac{d\Phi}{dt}$$

The negative sign (–) represents Lenz's Law, showing opposition to the change in flux.

DEFINE STATICALLY INDUCED AND DYNAMICALLY INDUCED EMF:

Applications :

Types of Induced E.M.Fs and Their Applications :

Mainly we have two types of e.m.fs. induced in a coil or conductor.

1) Statically Induced E.M.F - Created in Transformers.

2) Dynamically Induced E.M.F - Created in Generators.

Statically Induced E.M.F : The E.M.F induced in a conductor due to variation in the strength of magnetic field linking with the conductor, when both the magnetic field and the conductor are stationary, is called the statically induced E.M.F as shown in Fig. 8.7 (a).

In this method of getting E.M.F induced, neither the conductor nor the magnetic field moves, but the strength of the magnetic flux is varied.

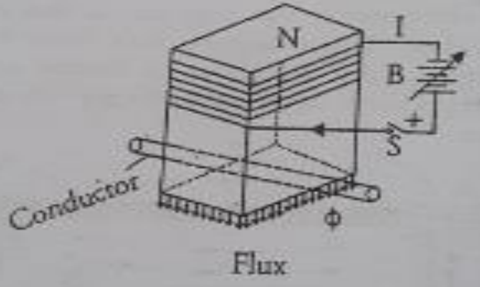


Fig. 8.7 : (a) Statically Induced E.M.F

In Fig. 8.7 (a), by varying the voltage applied to the coil, the current in the coil is varied. This in turn varies the strength of the magnetic flux, linking with the conductor. Hence, according to Faraday, E.M.F is induced in the conductor.

Application :

1. Statically induced E.M.F principle is used in all types of transformers, like power transformers, auto transformers, Distribution transformers, chokes, Radio coupling transformers, Reactors etc.

Dynamically Induced E.M.F : The E.M.F induced in a conductor, due to the relative motion between the magnetic field and the conductor, is called the dynamically induced E.M.F.

The relative motion between the conductor and the magnetic field is created by any one of the following two methods as shown in Fig. 8.7 (b).

a) By keeping the magnetic field stationary and moving the conductor in the magnetic field. (Adopted in D.C. Generators).

b) By keeping the conductor stationary and moving the magnetic field over the conductor. (Adopted in Alternators).

In either case there is a relative motion between the conductor and the magnetic field and hence the flux is cut by the conductor and E.M.F. is induced in it.

For getting dynamically induced E.M.F. the following three conditions are to be full filled :

1) Presence of magnetic field.

2) Conductor in the magnetic field and

3) Relative motion between the conductor and the magnetic field.

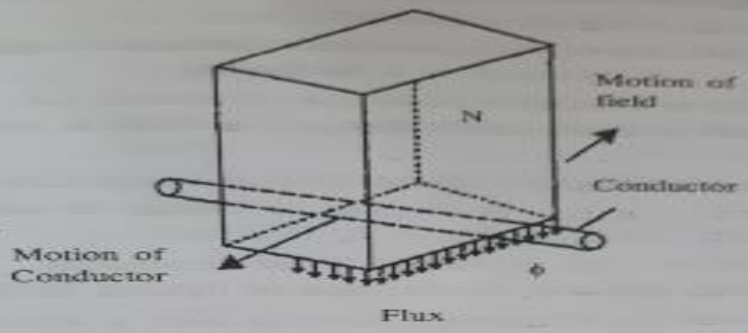


Fig. 8.7 : (b) Dynamically Induced E.M.F

Application :

1) Dynamically induced E.M.F. principle is used in D.C generators, Alternators, in cycle dynamos etc.

***NOTE:SIMPLE PROBLEMS ON ELECTROMAGNETIC INDUCTION ARE SOLVED IN THE NOTES.**